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Notes on gas as a weapon in modern warfare

Army War College (U.S.)

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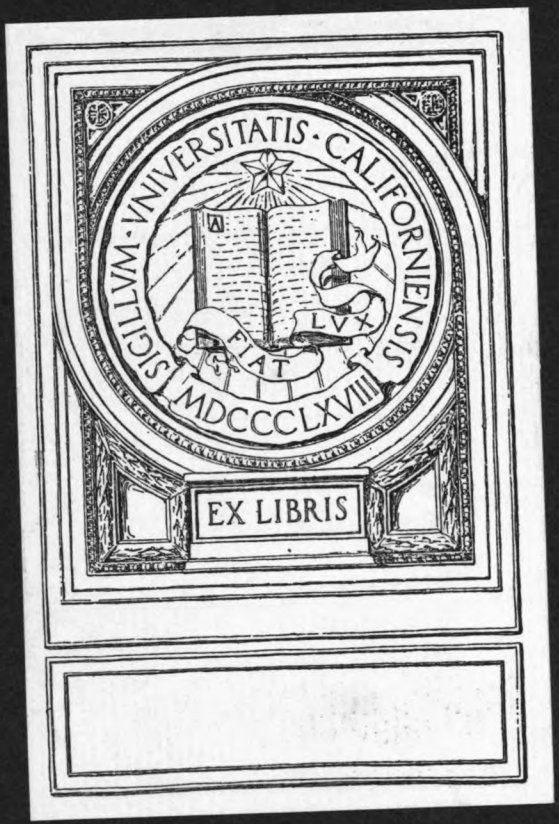
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NOTES ON
GAS AS A WEAPON IN MODERN WARFARE

COMPILED FROM
THE LATEST AVAILABLE INFORMATION

ARMY WAR COLLEGE
APRIL, 1917

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

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UNIV. OF CALIFORNIA

WAR DEPARTMENT
Document No. 577.
Office of The Adjutant General.

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WAR DEPARTMENT,
WASHINGTON, *April 28, 1917.*

The following Notes on Gas as a Weapon in Modern Warfare are published for the information and guidance of all concerned.

[2582933–A, A.G.O.]

BY ORDER OF THE SECRETARY OF WAR:

H. L. SCOTT,
Major General, Chief of Staff.

OFFICIAL:

H. P. McCAIN,
The Adjutant General.

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GAS AS A WEAPON IN MODERN WARFARE.

UNIV. CALIF.

The use of various gases as weapons of offense in the present war has become so general that in any training of troops in the future a thorough knowledge of the technique of gas attacks and the methods of defense against them must be included.

The use of gas, like many of the other weapons now in common use in the armies of Europe, such as the catapult, flame projector, trench knife, and sling, is an inheritance from the early ages, amplified, improved, and made more destructive by the aid of modern science.

The first recorded effort to overcome the enemy by the generation of poisonous and suffocating gases seems to have been in the wars of the Athenians and Spartans (431 to 404 B. C.), when in besieging the cities of Platea and Delium the Spartans saturated wood with pitch and sulphur and burnt it under the walls of those cities in the hopes of choking the defenders and rendering the assault less difficult. They also melted pitch, charcoal, and sulphur together in cauldrons and blew the fumes over the defenders' lines by means of bellows.

"Greek fire" was used by the Byzantine Greeks under Constantine about 672 A. D., to destroy the Saracens, and the Saracens, in turn, used it as a weapon of defense against the Christians during the crusades. This Greek fire had the double advantage of being not only inflammable, but also generating during the process of cambustion, clouds of dense, blinding smoke and gas of an asphyxiating character. (This gas, sulphurous dioxide, is one of the gases used to-day.) Its chemical composition was supposed to be a mixture of quicklime, petroleum, sulphur, and such other inflammable substance as pitch, resin, etc. Upon the addition of water the slaking process which

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the quicklime underwent generated enough heat to ignite the petroleum, which, in turn, ignited the resin, pitch, and sulphur. This flaming mixture was delivered against the enemy by means of fantastic syringes in the shape of dragons and other monsters with wide jaws.

The first use of gas in modern warfare occurred April 22, 1915, when the Germans liberated great clouds of gas against the allies' trenches near Ypres, with a resulting complete demoralization of the troops and a large number of casualties. Coincident with the use of the "gas cloud" the Germans began to use gas also in bombs, hand grenades, and shells. The world was astounded at this resurrection of an ancient form of warfare, strictly forbidden by The Hague convention, but new weapons in war demand that they be met with similar weapons, and a week later the allies had agreed to manufacture gas shells and use gas in other ways in retaliation. From this beginning, gas has now become recognized as one of the accepted arms of the military service and is being used very extensively in all armies, especially in the form of gas shells.

INSTRUCTION IN THE METHODS OF GAS WARFARE.

The importance of thoroughly instructing all soldiers in the methods of gas warfare and the methods of defense against it has been fully recognized in the armies of Europe. The whole object of such instruction is to make every man thoroughly familiar with the conditions under which he will have to meet gas, and to make him proficient in the necessary measures of defense. This instruction is both theoretical and practical. The theoretical instruction covers the methods of employing gases in attack, the character of gases used and their effects, while the practical instruction covers the methods of defense, including the actual exposure to gas. In both England and France each district has one or more special antigas schools, where specially selected officers and men are trained to enable them to impart this instruction to companies, troops, and batteries.

The school at Aldershot may be taken as a type. The training plant includes a lecture room with gassing apparatus and charts, a "gassing house," and an area in which model trenches and dugouts have been prepared.

The gassing house contains one room 15 by 15 feet, with corridor entrances on either side and double doors to each corridor.

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THE GAS ATTACK ON THE CANADIAN TROOPS NEAR YPRES.

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The purpose of these double doors is to prevent the escape of gas. To give the men practical experience in enduring asphyxiating gases, protected by masks they are shut up in the room, masks are adjusted, and the gas is turned on.

The dugouts have a corridor entrance to them from the trenches, and in place of doors wet blankets reaching down to the floor are hung at either end of the corridor. These wet blankets are to simulate the wet blankets which are actually used in the real trenches to prevent gas getting into the dugouts, and are used here to show the soldier that they really are a protection and keep out gas.

Trenches and dugouts so arranged are established at all training camps, and organizations are trained in turn in the actual experience of resisting gas attacks. They enter the trenches and dugouts; the alarm is given by beating on a gong, and gas is turned into the trenches and dugouts. At the beating of the gong each man must adjust his mask. Before being given this actual experience with gas, each man is given a thorough course of instruction in the character of gases and drilled into the methods of defense against them. In the 12 weeks' course of training laid down for the Infantry recruit he is given 1 hour antigas instruction each week. As a part of this instruction he is practiced in running and exercising while wearing his mask.

THEORETICAL INSTRUCTION.

Methods of making a gas attack.—Gases may be employed either in the form of "gas clouds" sent against the enemy's trenches by means of a favorable wind or liberated in the trenches by means of hand grenades, rifle grenades, bombs, and shells. There are various ways in which the gases forming the gas clouds may be liberated. The most primitive (the "stinkpot" method) is the building of fires in front of the trenches in which either smoke clouds may be generated by the burning of pitch and petroleum, or lachrymatory gases may be generated by the burning of sulphur or a derivative of formol. In the first case sulphurous anhydride is evolved and in the second formol in a gaseous state. This generating of gases by the burning of fires has been practiced to some extent in the present war and is exactly the method practiced by the ancients. The improved modern method, however, is the liberation of the gas from steel containers in which it is held under pressure in a liquid state.

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These containers are distributed in batteries of three or four at intervals of about 50 yards along the trenches opposite the line to be attacked. Tubes provided with a stopcock attachment are connected with the gas tanks and the end of the tube passed over the parapet. When an attack is intended a signal is given and the stopcocks are opened, allowing the gas to escape in the form of a dense vapor. This escape of the confined gas is accompanied by a low whistling sound which, at night, is frequently the only warning the opposing side has of the coming attack.

The success of the "gas cloud" is dependent on the atmospheric conditions. A calm night or day, with a gentle wind blowing in the right direction is essential. A strong wind distributes the gas too quickly and diminishes its concentration, and a variable wind is not to be depended upon; too much moisture in the air also neutralizes the gas somewhat and diminishes the force of the attack. Before a gas-cloud attack is made, therefore, the atmospheric conditions are studied, and the direction of the wind is determined by lighting small fires and watching the direction of the smoke, by letting up small balloons, or by the use of a weather cock. These methods are visible sometimes and may give warning of an impending attack.

The gases used being heavier than air (chlorine is two and one-half and bromine five times as heavy as air), when released under proper atmospheric conditions, move, or rather appear to roll, along the ground usually in the form of a dense greenish yellow cloud toward the lines of troops to be attacked, and when it reaches the trenches it settles down into all parts of them, penetrating the dugouts and bomb proofs and remaining sometimes for several days. The thickness of the cloud and the rapidity with which it approaches varies in accordance with the velocity of the wind. Gas attacks have been made with velocities varying from 3 to 15 miles per hour, i. e., from 1½ to 7½ yards per second. In an average 9-mile wind the gas would reach trenches 100 yards distant in 20 seconds.

While the gas-cloud form of attack, if successful, can produce a number of casualties, its operation is uncertain, and its approach can be anticipated if proper watchfulness is maintained. Efficient measures can be taken by trained troops to nullify its effects, and its military value, therefore, is probably not so great as when it is used in shells, bombs, hand grenades, etc. This method is a much more definite procedure and will prob-

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ably be used in all wars of the future. Gas used in this way has a distinct military advantage in that it is possible to place it exactly where it may be needed to form a gas barrage or a smoke barrage to prevent the bringing up of reinforcements or the retreat of defeated troops.

THROWING HAND GRENADES CONTAINING GAS.

Gas is used in shells of both large and small caliber, but the 5.9-inch shell seems to be the best medium for its transmission. These shells hold about 7 liters of a gas-producing liquid. They have a short ogival head and a long cylindrical body of thin steel, about one-fourth of an inch thick; closely fitted against

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the inside walls is a cylinder of sheet lead about one-eighth inch thick, which is filled with the gas-producing liquid and then tightly soldered. This lead container fills nearly the whole cylindrical portion of the shell. Just above it, but not resting on it, is the explosive, and above this, on the point of the shell, is a combination of time and impact fuse. The effect of the charge upon exploding is to tear open the head of the shell and the top of the lead container so as to allow the liquid to spill out and liberate the gas.

Hand grenades of various kinds, made of both glass and iron, and containing a quantity of gas-producing liquid are used in trench warfare, and iron bombs with a bursting charge of black powder and containing gas liquid are also used in trench mortars.

THE VARIOUS KINDS OF CASES.

(*a*) *Lachrymatory gases* (which cause an intense inflammation of the eyes with temporary blindness).

(*b*) *Suffocating gases* (which cause rapid death by suffocation).

(*c*) *Asphyxiating gases* (which are extremely severe in their action and cause in many cases immediate death, in others a lingering death after several days, and in still others permanent physical disability).

The lachrymatory gases are the ones most commonly used in projectiles. *The asphyxiating and suffocating gases* are the ones used in gas-cloud attacks, but they are also used in projectiles.

A great variety of acids may be used for the production of gases, and chemists in all armies are constantly experimenting with a view to perfecting new and more potent combinations. The ones most commonly used now, however, for the lachrymatory group are combinations of benzol and acetone, with chlorine and bromine, such as chloracetone, bromacetone, and benzyl bromide. The principal acids used for asphyxiating purposes are chlorine, bromine, and phosgene. These acids are abundantly produced in commercial processes of manufacture, are easily obtained, and answer every purpose. They are, however, with the exception of phosgene, easily neutralized by alkalies. In addition to these commoner acids, many other acids have been used. Some of them are hydrogen sulphide, sulphurous anhydride, various nitrous vapors, formol, arsene, and prussic acid.

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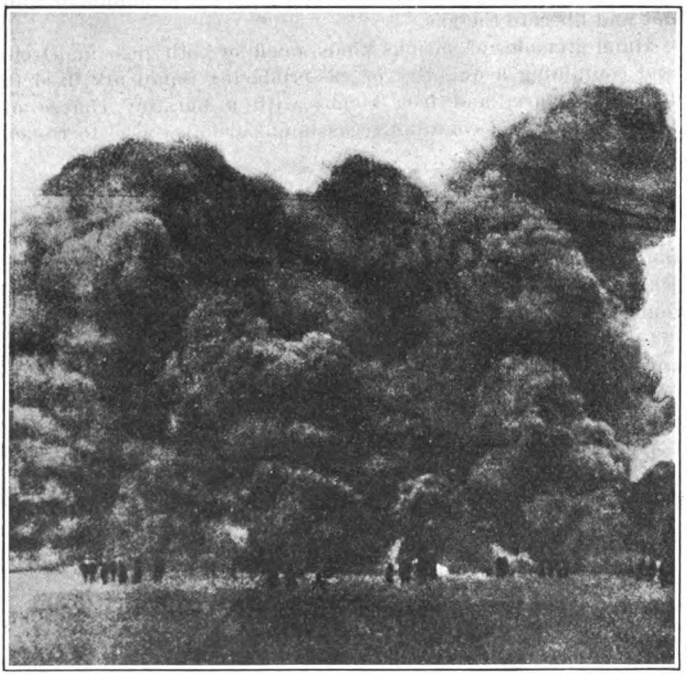
THE EFFECT OF GASES.

Certain gases, such as prussic acid, produce instant death by paralyzing the central nervous system, but the majority of the gases have a special affinity for the mucous membranes, and their systemic effect depends on the amount of damage they do to those tissues. The lachrymatory gases have a special action



CLOUD RESULTING FROM THE COMBUSTION OF HYDROCARBURETED COMPOUNDS.

This column of asphyxiating vapor is terrifying; it is about 30 meters high, and is very slowly dispersed by the wind.

on the membranes of the eye and upper air passages, and their effects, though severe while they last, are as a rule temporary. They cause a severe smarting pain and running of the eyes (tearing), and soon the lining of the eyelids become so swollen that vision is impossible. At the same time there is a dryness, burning, and smarting of the nose and throat, with coughing

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and sometimes vomiting. In three or four hours these symptoms begin to disappear and gradually the soldier recovers.

The asphyxiating and suffocating gases are far more severe in their action. Their potency can be realized when it is known that a dilution of 1:1,000 is fatal with chlorine and bromine, and 1:25,000 is fatal with phosgene. A dilution of 1:100,000 or more has a marked effect. These gases act to a less degree on the membranes of the eye than the lachrymatory gases, but their action is particularly virulent on the membranes of the respiratory tract, which they cause to swell rapidly and finally destroy. The result in edema of the lungs, accompanied by persistent coughing and spitting of blood, then great difficulty in breathing, the soldier becoming cyanosed and struggling for breath. Death may be almost instantaneous, or it may be postponed for several days, the sufferer in the meantime not being able to eat anything and undergoing great agony. Many of the cases in which recovery does take place develop later a chronic disease of the lungs.

METHODS OF PROTECTION.

The deadly character of gas attacks can be almost entirely obviated if the proper means of protection are known and strictly enforced. These are primarily:

1. *Prompt warning of an approaching attack;* and 2. *Prompt application of the gas mask.* The rapidity with which gas clouds travel make it essential that warning of an approaching attack be given without delay, and that troops adjust their masks as rapidly as possible.

Advance information of an attack can be frequently obtained by aeroplane reconnaissance and constant observation of the enemy's trenches by outpost sentries. These two sources of information should be continuously employed. The only certain signs of an actual attack, however, are:

(*a*) The whistling sound of the gas as it escapes from the containers.

(*b*) The smell of the gas.

(*c*) The appearance of a cloud of any color over the enemy's trenches.

(With all gases at night and with certain forms of gas in the daytime the cloud is not visible at a distance.)

Immediately upon the appearance of any of these signs the "gas alarm" should be given and masks put on instantly.

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GAS MASKS.

A perfect familiarity with the uses of the mask and its prompt application is the only certain means of defense. This has been proven very thoroughly in the present war. The casualties in the first gas attack at Ypres, where nothing was known as to the means of defense, were fully 25 per cent, while in recent attacks made on troops provided with the latest masks and thoroughly drilled in their use the casualties have been barely 1 per cent. In other instances, however, with the same masks, but in the hands of undrilled troops, the casualties have been large.

The development of gas masks has kept pace with the development of the use of gas in war. Within two days after the attack at Ypres 100,000 masks had been prepared by the women of France and sent to the troops at the front. These masks were, however, simply small pads of gauze and cotton tied over the mouth by means of strings and of course did not answer their purpose.

All of the gas masks in use to-day provide mechanical protection to the eyes by means of goggles and chemical protection to the air passages by means of a mixture of various elements which neutralize the chemical action of the gas. The fundamental principles underlying them all are (*a*) the protection of the eyes without interference with vision and (*b*) the exclusion from the air passages of all air except that which has passed through a neutralizing element. The first is accomplished by means of goggles or eyepieces which fit tightly around the eyes. The second is effected by means of various mechanical devices in which all the inspired air is made to pass through either a pad or cloth which has been previously treated with neutralizing chemicals or through a metal container which is kept filled with a neutralizing mixture. The latter has proven the best device and is now in use in practically all armies.

The English type of this mask is known as "the small box respirator." It comprises an impervious face piece or mask containing windows for the eyes, which is held in place by rubber bands around the head, a tin can or box carried in a small haversack, and a flexible, noncompressible tube connecting the box with the face piece. Inside the face piece is a small wire clamp which, applied to the nose, prevents air from being inhaled through the nasal passages. When the face piece is ad-

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justed and the nose clamp in position, the wearer takes the end of the flexible tube in his mouth, and both inspiration and expiration is carried on through this tube. The expired air finds exit through a rubber check valve just outside the mask,

HAND TO HAND COMBAT BETWEEN GERMAN AND ENGLISH TROOPS FOLLOWING A GAS-CLOUD ATTACK.

The men on the right (English) are wearing the tube helmet type of gas mask. The man on the left is wearing the German mask.

while the inspired air is taken in through a wire netting window in the bottom of the box. In this box the neutralizing mixture is arranged in five layers, and in its passage through these five layers the gas-laden air is robbed of its poisonous qualities.

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The German mask is somewhat similar to the English mask, but the container for the neutralizing mixture is screwed on to a ring in the bottom of the mask. Inspired air and expired air both pass through the container. In addition to the small box respirator type of mask, every English soldier is provided with a mask of the "tube-helmet" type, to be carried as a reserve. This mask is really a cloth or flannel hood with a skirt long enough to be tucked under the collar of the coat. It is provided with eyepieces and a tube and check valve arrangement, through which the expired air escapes. Inspired air comes through the cloth of the mask, which has been impregnated with chemicals. In addition to a mask somewhat similar to the English "respirator" type, the French Army is equipped with a mask known as the M2 type.

This mask has a face piece with celluloid windows for the eyes and a crescent-shaped piece passing under the chin and well up to the ears. The mask below the goggles is lined with a quilted pad of gauze soaked with neutralizing chemicals. A piece of thick sheeting of pure rubber goes around the goggles on the inside and is stitched between the layers of quilted gauze to prevent air leaks. The face piece on the outside is protected by a layer of waterproof cloth.

As gases have an effect on horses similar to that on men, masks are now being provided. Horses and all animals when in the danger zone are masked.

PRACTICAL INSTRUCTION.

Practical instruction should include the mechanism of the gas mask, and the manner in which it is used, and should be so arranged as to train the soldier in the quick and accurate application of his mask and to accustom him to the performance of his usual duties while wearing it. In other words, every effort should be made to familiarize him with "the feel" of his mask and to establish his confidence in it.

The care of the mask should be explained and the absolute necessity for having it at all times nearby and in perfect condition dwelt upon.

The main point to be impressed upon the soldier is that the chemical material in the mask acts as a filter and that all air breathed into the lungs must first pass through this chemical material in order that the poisonous qualities of the gas may be

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TRAINING IN THE ADJUSTMENT OF THE MASK.

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eliminated. There must therefore be no leaks in the mask, nor must it be removed until orders to do so have been given by the noncommissioned officer in charge of the trench section.

Mask Drill.—Mask drill should be carried out frequently by all ranks. It should aim at teaching the quick adjustment of the mask under all conditions, accustoming men to wearing them for a long time and taking exercises in them. The following points should be noted:

(*a*) Men should be timed in removing the mask from container and getting it properly adjusted on the face. This should only take a few seconds, and the importance of developing quickness and dexterity in the men in the application of their masks can not be overestimated. Men should be taught to hold their breath while putting on the mask, as a few breaths drawn in concentrated gas may be followed by serious results.

(*b*) Practice simple movements while wearing mask, physical drill, setting-up exercises, short-running exercises, etc. At first these exercises should not exceed 15 minutes but should be gradually extended. Men must be accustomed to wearing their masks for at least one hour.

(*c*) The care of the mask, method of keeping the eyepieces clean, etc.

(*d*) Practice in bombing, rapid loading, and aiming, judging distance and range practice while wearing the mask.

(*e*) Practice in attacking trenches and in use of bayonet.

As an evidence of the minuteness and exactness which is required in instructing soldiers in the application of the gas mask, the following may be quoted from the English drill regulations:

DRILLS WITH SMALL BOX RESPIRATORS.

Practice A.—Adjustment of the respirator box in the "alert" position.

On the command "Gas alert" hang the box respirator around the neck with the press buttons next the body. With the right hand seize the satchel by the leather tab, with the left hand seize the sling by the brass button and slip this into the leather tab. Undo the press buttons closing the satchel, tuck in the slack of the sling into the left-hand compartment, so that it lies under the mask.

The length of whipcord will then be withdrawn from the right-hand compartment, passed through the ring on the right of the

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satchel, and carried round the waist to the ring on the left, where it is fastened.

The press button closing the satchel will be left undone, but the flap will be put in position to keep the respirator from wet.

TRAINING RECRUITS FOR ATTACK WHILE WEARING MASKS.

TRAINING IN THE USE OF THE BAYONET WHILE WEARING THE MASK.

Practice B—Drill by numbers to obtain correct adjustment of the small box respirator.

NOTE.—This drill is to be carried out alternately with one "judging the time," i. e., as quick adjustment as possible. It is most important, and complete adjustment must be obtained by all ranks in six seconds.

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Adjust the respirator in the alert position, with satchel covered but not buttoned.

1. On command "One" press down both thumbs between the satchel and the body and open the satchel flap. Immediately seize the mask with the right hand, the metal breathing tube just outside the mask being in the palm of the hand and the thumb and first finger grasping the wire frame of the nose clip.

2. On the command "Two" bring the mask smartly out of the satchel and hold it in both hands with all the fingers outside round the binding, and the two thumbs inside, pointing inward and upward under the elastic. At the same time throw the chin well forward ready to enter the mask opposite the nose clip.

3. On the command "Three" bring the mask forward, digging the chin into it, and with the same motion bring the elastic bands back over the crown of the head to the full extent of the retaining tape, using the thumbs.

4. On the command "Four" seize the metal breathing tube outside the mask, thumb on the right, fingers on the left, all pointing toward the face. Push the rubber mouthpiece well into the mouth and pull it forward until the rim of the mouthpiece lies between the teeth and the lips and the two rubber grips are held by the teeth.

5. On the command "Five" adjust the nose clip to the nose, using the thumb and first three fingers of the right hand. Come smartly to attention.

Practice C—Drill to teach cleaning of eyepieces.—On the command "Clean eyepieces" the right eyepiece will be gripped between the thumb and first finger of the left hand. The first finger of the right hand will then be pushed gently into the flap of the mask behind the right eyepiece, which will be cleaned with a gentle circular motion.

The left eyepiece will be cleaned in a similar way.

Practice D—Drill to teach method of giving orders.—It is first explained to a squad that the nose clip must not be removed to talk, and that before each sentence is spoken a long breath must be taken and the mouthpiece removed sideways from the mouth by turning the metal tube outside the mask to one side. After speaking the mouthpiece is replaced.

The squad should then be numbered off, extended to four paces, and orders passed along the line.

Officers and noncommissioned officers will receive instructions in practice D.

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Practice E.—Drill to teach method of clearing mask from gas which may have leaked in and is affecting the eyes.—Press the mask close to the face, forcing out foul air round the sides, and then fill again with air from the lungs by blowing out round the mouthpiece.

Practice F.—Drill to teach method of testing whether trench or dugout is free from gas.—With right hand open the face piece away from the right cheek, then loosen the nose clip on the nose and smell gently (do not take a breath). If gas is smelled, the nose clip and mask are replaced. Then as in drill "E."

Practice G.—Ordinary infantry drill will be carried out while wearing the mask. This will include doubling for at least 200 yards at a time. Marching order will be worn. Musketry and bombing instruction and training of specialists (including artillery, machine gunners, signalers, R. A. M. C.) will also be carried out.

Practice H.—Drill to teach changing from the small box respirator to the tube helmet.—On the command "Change" hold the breath, knock off the steel helmet with the right hand, pull off the mask by inserting the fingers of the left hand under the mask at the chin, and then get on the tube helmet. When the chin grip is obtained, commence breathing again.

Protection must be obtained in 10 seconds or less.

NOTE.—(*a*) If after wearing for a long time the pressure of the nose clip becomes unbearable, it may be relieved for a few moments by taking off the pressure without removing clip.

(*b*) *Removing masks.*—It must be seen that when masks are removed this is done without strain on the face piece or elastic. On the command "Take off masks," insert the fingers of the left hand under the mask at the chin, bend the head forward, at the same time removing the mask with an upward motion of the left hand.

(*c*) After all drill the mouthpiece must be disinfected, the mask wiped dry, folded correctly and put away in such a way that the rubber valve is not bent.

Having become thoroughly accustomed to the use of the mask, all ranks should be given an actual exposure to gas in the training trenches. This exposure should simulate in every way an actual gas attack. At the gas alarm every man should promptly adjust his mask, and inspection should be made to see that this has been properly done. The gas should then be

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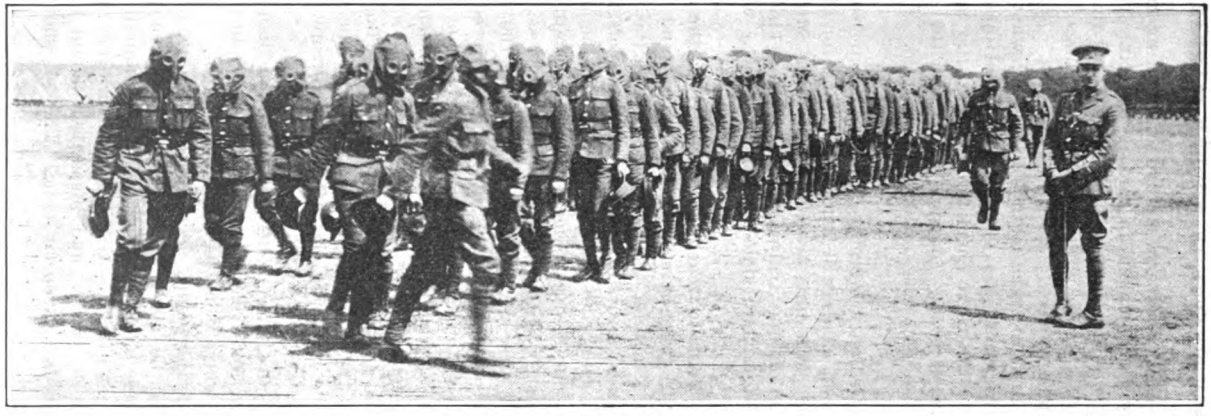

. TRAINING RECRUITS.

Marching while wearing gas masks. The tube helmet type of mask now carried by each English soldier in reserve.

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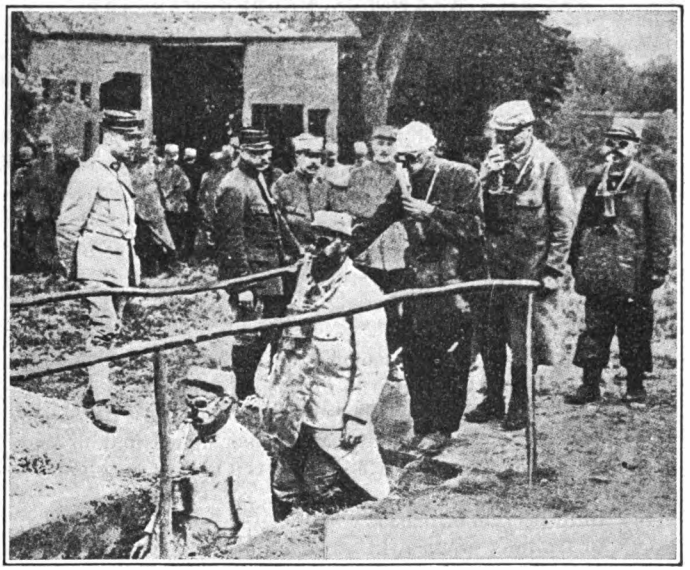

TRAINING TROOPS TO ACCUSTOM THEM TO THE POISON-GAS ATTACKS.

Soldiers wearing the protective masks descending an underground chamber filled with poison gas.

BOX RESPIRATOR TYPE IN USE IN THE FRENCH ARMY.

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turned into the trenches and the men kept in it for some time. Practice in clearing the trenches and dugouts of gas should be given, and men trained in the use of the gas fans and sprayers. Finally they should be practiced in the methods of determining whether or not all gas had been gotten rid of and if the mask can be safely removed.

GENERAL REGULATIONS.

The following general regulations governing gas attacks should be published, and all officers and men should be required to be familiar with them:

1. Every officer is responsible that the men under his command are properly instructed in defensive measures against gas attacks, and that standing orders on the subject are thoroughly understood. The experience in Europe has shown that in order to reduce gas casualties to a minimum the utmost care must be taken—

(*a*) In inspection of masks.

(*b*) In training all men in quick adjustment of their masks under all conditions.

(*c*) To insure that every man, whether in front or in the supporting lines, shall be given immediate warning of an impending attack.

If the above conditions are fulfilled and the nature of the gas attack understood and protective measures are carried out automatically as the result of effective training, the effect of a gas attack becomes very small.

The rapidity with which the gas cloud travels makes it essential that troops should adjust their masks as rapidly as possible, and that warning of an approaching gas attack should be given without delay.

2. Wind observations.—Wind observation should be made at regular intervals by officers detailed for that duty in all units in the front line, so that warning may be given when conditions are favorable for a hostile gas attack.

3. When the wind is favorable for a gas attack.—(*a*) At night sentries should have at least two men in reach of them so that the alarm can be spread rapidly.

(*b*) A sufficient number of sentries should be posted over large dugouts or groups of dugouts to insure that all sleeping men can be aroused without delay.

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(*c*) When thought necessary an additional inspection of masks should be made.

(*d*) Sentries should be told off for warning the company and regimental headquarters, and the artillery observation post, if there be one in the trench.

(*e*) At night and at all times when a gas attack is expected men in advanced trenches will have the masks in instant readiness to apply.

(*f*) Commanders of all units in camp or billet in rear of the trenches, but within the area of danger from gas, will make the proper arrangements for giving the alarm and rousing all men on receipt of information of a gas attack.

4. Gas alarm.—Appliances for giving the alarm in case of gas attack must be carefully arranged in advance. These should be of two kinds. The first in the form of gongs or bells, etc., at each sentry post which will be beaten or rung directly gas is detected and will arouse the men in their immediate vicinity, the signal being passed along by all sentries as soon as heard. The second kind will be for the purpose of conveying the alarm to troops in support or reserve lines and should be loud horns worked by compressed air or motor (Klaxon horns) in order to supplement wire communication should the latter break down.

No reliance can be placed on method of communication involving the use of the lungs, e. g., bugles, whistles, or telephones. Sentries must be prepared to give the alarm on the first sign of gases, a few seconds delay may involve serious consequences.

5. **Action to be taken on gas alarm signal.**—(*a*) Everyone put on masks.

(*b*) Rouse all men in trenches and dugouts. Warn officers and artillery observation posts, etc.

(*c*) Company commander call for artillery support and warn headquarters and troops in rear by means of prearranged signals.

(*d*) Infantry man parapets and open fire with rifle and machine guns, and, where practicable, trench mortars on the trenches from which the gas is issuing.

(*e*) Let down and fix carefully the blanket curtains at entrances to cellars and dugouts so protected.

6. **General precautions during gas attacks.**—Officers and noncommissioned officers must not take off their masks to give orders. Men must always be on the lookout to help each other

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in case a mask is damaged. When a man is wounded, he must be watched to see that he does not remove his mask. If necessary, his hands should be tied.

Men must be warned that if they are slightly "gassed" before adjusting their masks they must not remove them. The effect will wear off. After the cloud has passed and the trenches been cleared of gas by the apparatus provided for the purpose, the noncommissioned officer in charge of each trench section will assure himself that the trench is free from gas by raising his mask slightly, and will then issue the order to take off masks. **Men will on no account take off their masks until the order to do so has been given.** Dugouts and bombproofs must be entered with caution even after the trenches are clear, as gas frequently remains in them some hours.

Rifles and machine guns should be cleaned after an attack, as the gas affects them injuriously. If ammunition boxes are kept closed and machine guns, rifles, and ammunition not in boxes are kept well oiled and are fired occasionally during a gas attack, there is little risk of jamming. Oil cleaning will prevent corrosion for 12 hours or more, but the first available opportunity should be taken to dismantle the gun and clean the parts in boiling water containing a little washing soda. If this is not done, corrosion continues slowly, even after the oil cleaning, and may ultimately put the gun out of action.

Battery commanders should be reminded that aiming posts are liable to be obscured by the gas cloud, and that arrangements should be made in every battery to meet this eventuality by providing gun pits with means to check the line of fire, if necessary, without depending on the aiming posts.

7. **Masks.**—The mask is the main defense against a gas attack, and great care must be taken by officers to insure that the masks are in good order and that the men have been trained in their use. Masks issued to officers and men should be invariably kept on the person at all times. This refers not only to units in the trenches, but to all units and individuals when within 4 miles of the front line. They will be carried in containers on the outside of the coat or overcoat so that they are readily accessible at all times. They must be kept from exposure and wet and only removed from the containers for inspection.

Masks should be inspected once a week or more frequently if a gas attack is imminent. Great care must be exercised to see that they are at all times in perfect conditions. To prevent dim-

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ming of the eyepieces from condensation of moisture a proper chemical paste should be issued, to be applied to the inner surface of the windows. A little of the paste should be applied with a dry rag to the inside of the eyepieces, rubbing it hard into the glass. Then polish off as much as possible with a fresh rag, leaving the glass quite clear. This process must be repeated at each weekly inspection and after the goggles have been worn.

8. **Gas-shell attacks.**—The purpose for which gas shells are usually employed is to produce a barrage to prevent the bringing up of supports.

The liquid contained in these shells is usually the lachrymatory gas and converted into a dense white cloud of vapor by the explosion. This causes intense irritation and watering of the eyes, and is often sufficiently concentrated to irritate the throat and cause coughing and sometimes vomiting, but is not deadly like the asphyxiating gases. The latter are sometimes used in shells, however, so that upon the first intimation of a gas-shell attack the mask should be applied.

9. **Methods of clearing gas out of shell holes and trenches.**—During an attack the gas sinks into the dugouts, and when gas shells are used it sinks into the crater made by the shell and remains in these places a long time, as it is difficult to clear out. Gas may be almost entirely kept out of dugouts by hanging damp blankets over the entrances into them. This method should be universally adopted by artillery batteries, at regimental, brigade, and division headquarters, and wherever dugouts and cellars are used within the shell area. The blankets must be kept wet to effectually exclude the air currents. Shell holes which are so situated as to be obnoxious should be filled up with fresh earth, care being taken to cover up all places around the hole where the chemical liquid from the shell has dropped. Shell holes so treated should not be disturbed, as the chemical is not destroyed by burying, and only slowly disappears.

After the cloud has passed gas may be cleared out of the trenches by the use of chemical sprayers and fans. These should be distributed at easily accessible points in or near the trenches and protected from shell fire. These sprayers are similar to the tree sprayers of commerce and are kept filled with a liquid alkali which has the property of neutralizing asphyxiating gases but has no effect on lachrymatory gases. The latter must be dissipated by ventilation of dugouts and the

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use of fans. When a carbon monoxide gas is present in dugouts the ordinary mask is no protection. For this reason special oxygen containers must be provided for use of men engaged in clearing out the dugouts. This latter is accomplished by burning waste soaked with crude oil in an iron firepot. Where the dugouts are properly ventilated the heated air causes a current which quickly clears the dugout. Each company should have a noncommissioned officer in charge of a squad of men trained in the care and use of the sprayers and fans. On taking over trenches this gas noncommissioned officer will take over from the outgoing gas noncommissioned officer the sprayers and fans and will see that each is in good condition and that each sprayer is provided with solution. A man will be assigned to each sprayer. He will be responsible for testing it every day, and in case of gas attack he will stand by to use it when ordered. Every company commander will be held responsible that all the above measures are properly applied from the moment that he takes over a sector of trench.

THE TACTICAL EMPLOYMENT OF GAS IN OFFENSE.

The above résumé of the use of gas in the European armies deals entirely with the question of defense against gas attacks and the precautions and methods of instruction that must be instituted to minimize their effects. Gas having been generally adopted in all armies, however, a knowledge of the technique of its employment in offense must also be considered.

As has been noted above, gas may be employed in the form of gas clouds or waves, gas shells, gas trench mortar bombs, hand bombs, and grenades. The proper use of gas in the form of a cloud attack is of so technical a character that its employment should be delegated to specially trained gas companies attached to each division. In the English Army an entire brigade of Royal Army engineers has been organized for the gas offensive. This brigade is under the command of a general officer attached to army headquarters. When a gas-cloud attack has been decided upon the gas officer should make a survey of the sector involved and designate the location of the batteries of gas containers. These batteries, which may vary from 3 to 12 containers, are placed in specially prepared emplacements under the front line parapets and thoroughly protected from shell fire. Inasmuch

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as the trenches never follow a straight line the batteries must be so located that when the gas is released it will not "enfilade" the trench containing them. Advantage must be taken of salients so facing the enemy that the wind will carry the gas in the proper direction. The best distribution of the gas can be accomplished with batteries placed at intervals of from 30 to 40 yards.

The weather conditions being of such great moment in the proper accomplishment of a gas-cloud attack, they should always be studied thoroughly. To this end meteorological stations should be established along the front and daily observations recorded, tabulated, and charted. The ideal weather is a gentle wind blowing in the right direction at a rate of 4 to 6 miles per hour; fairly high humidity, 40 to 60 per cent, and an overcast sky. The upward current of warm air on a sunny day rapidly dissipates the gas and on such a day the best time for attack is in the early morning or late afternoon.

The order for a gas attack should be given in detail. It should state that at ——— hour on the first day when weather conditions are suitable a gas attack will be made on ——— sector of the front and the number of gas waves (rarely more than three) and the time for releasing each wave (so many minutes after ——— hour) will be started. Each day of the week should be given a code designation for some days in advance. By this means when the proper weather condition arrives, notification to attack can be given by signaling the code name. The artillery should have orders to open fire on the enemy trenches immediately after the gas wave has arrived and a heavy barrage fire also instituted to prevent the bringing up of reinforcements. For this barrage gas shells are especially useful.

METHOD OF MAKING A GAS ATTACK.

The gas-wave attack is practically always followed by an infantry attack, and therefore the most perfect coordination is necessary between the "gas detail," the artillery, and the infantry. When an attack is to be made, men are placed in charge of each battery to release the gas when the order is given. Each battery is connected by telephone with an officer of the gas service responsible for a given sector of the front, and he in turn with the line officer commanding that sector. The latter is

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connected with local and distant meteorological stations and with artillery headquarters.

The time for delivering the infantry attack will vary somewhat with the atmospheric condition under which the gas was liberated. Sufficient time should elapse for at least part of the gas to have been disseminated, for with an efficient barrage fire there is little chance of reinforcement being brought forward.

Gas-shell attacks are also dependent to some extent on the condition of the weather. Inasmuch, however, as by means of projectiles the gas can be liberated directly in the enemy's lines, weather conditions are not nearly so important as they are in the gas-cloud attack.

The employment of gas shells may be in conjunction with a gas-cloud attack, or an infantry attack without a preliminary gas-cloud attack. As mentioned above, their greatest usefulness is in establishing a heavy barrage to prevent the bringing up of reinforcements. They may also be used for a preliminary bombardment of the trenches, the noxious gases they liberate materially weakening the defense in many instances. Gas shells are also of distinct value in directing artillery fire.

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